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HAWAII AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF HAWAII

Honolulu, Hawaii

PLANT PRODUCTS OF ECONOMIC POTENTIAL IN HAWAII. II. TANNINS

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INTRODUCTION

Animal skin when placed in an aqueous infusion of bark, leaves, pods, or woods of certain species of plants is converted into a stable product, leather. The active ingredients present in this infusion are called vegetable tannins and the process is known as vegetable tanning.

Prior to 1884, most types of leather were tanned with these materials. A chemical method of tanning with chrome salt was developed in that year, and a single-bath method of tanning in basic chromic chloride was developed in 1893. This latter method, with subsequent refinements in technique, is commonly used today. Vegetable tannins, however, have remained necessary for tanning heavier leathers.

Recent research carried out to develop synthetic materials to replace vegetable tannins has resulted in the products known as "syntans." Their lack of weight-producing qualities, however, makes them unsuitable for replacement of vegetable tannins in heavy leather tanning, and raw materials and manufacturing costs also make them considerably higher in price than natural tanning materials *(7)*.

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Demand for vegetable tannins has increased as a result of their use in industries other than leather manufacture. Drillers of oil wells have discovered that "quebracho" tanning extracts treated with alkali help in regulating the viscosity and consistency of drilling muds. Several thousand tons of tannin extract are used annually for this purpose *(7, 8)*. Some vegetable tannins are also used in clay suspension for ceramics and refractories. Others are used in the manufacture of cement by the wet slurry process *(10)*, in plastics, and in the prevention of corrosion in low- and medium-pressure boilers *(3)*.

The United States is almost entirely dependent upon foreign sources for vegetable tannins. Vegetable tannins are imported from many parts of the world and many of the plants from which tannins are derived are destroyed and are not replaced (reforested), so the world supply is diminishing *(7)*.

The United States Department of Agriculture has to some extent explored the possibilities of utilizing domestic plants which can be grown as farm crops as a source of tanning materials. Studies have been made on both sumac *(2)*, and canigre *(11)* cultivation.

The Department of Agricultural Biochemistry of the Hawaii Agricultural Experiment Station has recently conducted a survey to determine the tannin content of certain plants growing in Hawaii. This is a preliminary report on the survey.

MATERIALS AND METHODS

The majority of the plant materials were collected at the Lyon Arboretum in Honolulu. A few samples were collected at the Foster Botanical Gardens, Hanauma Bay Park, and on the islands of Hawaii, Maui, and Kauai.

Bark and leaf samples were taken for each plant, but there were few cases in which only bark or leaves were collected. Some fruit and pod samples were also included.

When old trees were sampled, bark was collected from young branches as well as the trunk.

The plant materials were dried at 70° C. in a forced-draft drying oven overnight and ground to pass a 20-mesh screen.

Total solid, soluble-solid, non-tannin, and moisture determinations were made by the official method of the American Leather Chemist Association *(1)*.

RESULTS

Eighty-six plant species in 25 families were analyzed for total solids, soluble-solids, insoluble-solids, non-tannin, and tannin. The results are shown in table 1. The moisture content of air-dried samples was between 10 – 12 percent.

Among the 174 samples analyzed, 8 leaf, 10 bark, and 1 fruit sample showed more than 20 percent tannin.

Of the plants listed, 14 have been previously analyzed elsewhere for their tannin content. These were included in order to compare the tannin content of plants grown in Hawaii with those grown elsewhere. The results for the other plants are being reported for the first time, as far as the authors are aware.

DISCUSSION

Thirty-four percent tannin was found in the leaves of *Rhus taitensis*. This plant is indigenous to Tahiti and is related to the sumac used by the leather industry. The use of sumac has, however, declined in recent years.

Howes *(6)* reports the tannin content in plants is influenced by factors such as altitude, temperature, location, soil, rainfall, and age of the plant. Some examples of this environmental influence occur in the data. *Terminalia arjuna, Terminalia catappa,* and green wattle grown in India have been reported to contain 19, 12 – 25, and 31 – 42 percent tannin, respectively *(13),* while the same species growing in Hawaii contain 24, 29, and 23 – 32 percent tannin, respectively. The observed lack of agreement may be solely due to differences in the analytical methods used. This could account for the apparent environmental effects discussed above.

Acacia decurrens has a good quantity of tannin in the bark. This plant was cultivated in Hawaii at one time *(12)* and tannin production was considered a possible minor industry. During the period from 1888 to 1893, considerable interest was taken in wattle planting in Hawaii. However, the development of the sugar industry diverted attention from this project.

The husk or pericarp of macadamia fruit contains 10 – 14 percent tannin. Eastwood *(5)* reported that the tannin content in the hulls of Australian macadamia is approximately 14 percent and could be useful to the leather industry. However, this source of tannin has not been utilized on a commercial scale.

Several factors must be considered before conclusions on the economic possibilities for the development and utilization of available tannin supplies can be reached. These include quantities available, accessibility, tannin content, possible by-products, extract production, and transportation *(10)*. This report is concerned only with the tannin content of possible source plants in Hawaii.

SUMMARY

Eighty-six plant species, in 25 families, have been investigated for their tannin content. The results show 15 species contain more than 20 percent tannin in their bark or leaves. The 21–34 percent range of tannin content is lower than the commercial sources of tannins.

The highest tannin content found is 34.2 percent in the leaves of *Rhus taitensis*.

The tannin percentage obtained for some local plants varies with the results of analyses of the same material from locales other than Hawaii. This discrepancy may be due to environmental factors or to difference in the methods of analysis.

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TABLE 1. The Tannin Content of Some Plants in Hawaii

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN% (LITERATURE)
ANACARDIACEAE						
Anacardium excelsum	B	33.00	29.83	17.13	12.70	
	L	42.70	39.78	19.20	20.58	
Anacardium occidentale	B	51.30	43.54	19.17	24.37	9.0 (*13*)
	L	34.65	30.43	18.45	11.98	
Mangifera indica	B	34.23	30.93	15.21	15.72	
	L	32.96	31.41	18.09	13.32	
Rhus semialata var. sandwicensis	B	38.25	32.64	19.43	13.21	
Rhus succedanea	B	30.70	27.13	13.58	13.55	
	L	38.56	34.99	21.93	13.06	20.0 (*13*)
Rhus taitensis	B	42.10	38.28	19.81	18.47	
	L	61.01	56.38	22.16	34.16	
Schinus terebinthifolius	B	47.50	40.73	23.65	17.08	
	L	35.20	33.35	16.89	16.46	
Semecarpus anacardium	B	18.70	16.94	11.99	4.95	
	L	27.30	24.63	16.45	8.18	
APOCYNACEAE						
Cerbera odollam	B	39.60	37.93	34.37	3.56	
	L	44.46	44.08	40.17	3.91	
Joannesia princeps	B	26.70	24.48	12.40	12.08	
	L	33.20	31.53	16.98	14.55	
	Fruits	25.22	21.60	16.82	4.78	
Ochrosia acuminata	B	36.70	33.83	31.54	2.29	
	L	39.42	37.20	33.27	3.93	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
Ochrosia elliptica	B	30.35	28.08	23.57	4.51	
	L	36.96	34.75	31.99	2.76	
Tabernaemontana crassa	B	25.52	23.08	20.53	2.55	
	L	27.20	25.88	23.20	2.68	
AQUIFOLIACEAE						
Ilex paraguariensis	B	28.61	26.90	15.31	11.59	
	L	35.23	34.12	23.45	10.67	
CAPRIFOLIACEAE						
Sambucus canadensis	B	24.30	22.98	17.65	5.33	
	L	41.80	40.98	34.81	6.17	
COMBRETACEAE						
Terminalia arjuna	B	43.32	35.35	10.74	24.61	18.0 - 24.0 (*13*)
	L	41.16	38.08	17.37	20.71	
Terminalia belerica	B	25.03	22.88	10.32	12.56	
	L	31.90	29.11	15.05	14.06	
Terminalia catappa	B	42.64	37.23	7.63	29.60	12.0 - 25.0 (*13*)
	L	33.66	30.94	15.66	15.28	
Terminalia edulis	B	26.00	22.77	7.03	15.74	
	L	32.76	30.71	10.55	20.16	
Terminalia melanocarpa	B	24.00	22.51	8.41	14.10	
	L	47.20	45.40	20.16	25.24	
Terminalia muelleri	B	27.40	25.18	8.60	16.58	
	L	44.88	39.94	15.08	24.86	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
COMPOSITAE						
Erechtites hieracifolia	B	26.60	26.28	23.65	2.63	
	L	39.60	37.91	27.76	10.15	
Eupatorium riparium	B & Root	34.80	34.46	32.96	1.50	
	L	36.00	33.15	22.52	10.63	
Pluchea odorata	B	39.69	34.80	15.14	19.66	
	L	29.62	27.33	18.75	8.58	
DICKSONIACEAE						
Cibotium chamissoi kaulf	B	6.13	5.63	2.90	2.73	
	Stem	36.57	34.78	25.78	9.00	
	Core	56.18	55.35	48.39	6.96	
Cibotium splendens	Leaf stem	16.60	15.44	11.86	3.58	
	L	29.70	28.25	22.38	5.87	
DILLENIACEAE						
Dillenia indica	B	33.68	30.26	16.01	14.25	
	L	36.40	35.86	18.44	17.42	
	Fruits	59.76	50.89	19.51	31.38	
Dillenia philippinensis	B	23.40	19.48	7.42	12.06	
	L	29.91	26.10	14.10	12.00	
	Fruits	31.60	27.47	14.48	12.99	
Wormia (unknown)	B	34.21	27.88	11.26	16.62	
	L	28.93	25.18	16.91	8.27	
EUPHORBIACEAE						
Aleurites moluccana	B	24.72	23.02	7.28	15.74	5.0 22.0 (6)

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
Codiaeum variegatum	B	32.60	24.16	8.85	15.31	
	L	35.56	33.61	14.87	18.74	
Macaranga grandifolia	B	23.85	20.86	15.02	5.84	18.0 (6)
	L	26.52	23.69	15.52	8.17	
Manihot utilissima	B	30.40	28.03	23.47	4.56	
	L	31.36	29.78	26.20	3.58	
Phyllanthus emblica	B	44.10	38.56	12.18	26.38	24.0 (6)
	L	35.00	32.53	23.24	9.29	
GOODENIACEAE						
Scaevola frutescens	B	41.98	41.23	36.66	4.57	
	L	33.79	33.75	28.93	4.72	
GUTTIFERAE						
Garcinia benthami	B	24.85	21.23	8.45	12.78	
	L	34.73	31.86	16.11	15.75	
Garcinia xanthochymus	B	27.50	24.11	15.87	8.24	
	L	32.55	29.53	19.17	10.36	
HERNANDIACEAE						
Hernandia sonora	L	33.30	32.16	26.41	5.75	
LEGUMINOSAE						
Acacia (unknown sp.)	B	30.90	29.53	17.92	11.61	
	L	45.25	42.64	36.30	6.26	
Acacia catechu	B	14.20	12.36	4.54	7.82	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
Acacia koa	Young B	25.91	23.60	19.01	4.59	
	Old B	40.90	37.25	8.59	28.66	18.0 (*13*)
	L	38.00	37.64	23.59	14.05	
Acacia confusa	B	29.14	26.53	17.67	8.86	12.0 - 14.0 (6)
	L	28.70	24.60	19.09	5.51	
Acacia decurrens (from Haleakala, Maui)	B	41.13	37.51	14.47	23.04	18.0 - 51.0 (*13*)
	L	30.89	27.55	16.60	10.95	
Acacia decurrens (from Kaupakalua, Maui)	B	45.62	41.55	11.70	29.85	18.0 - 51.0 (*13*)
Acacia decurrens (from Kokee, Kauai)	B	49.10	46.17	13.84	32.33	18.0 - 51.0 (*13*)
Albizzia carabea	B	7.21	6.73	5.12	1.61	
Andira inermis	B	23.90	21.33	10.51	10.82	
	L	18.75	17.83	13.38	4.45	
Bauhinia monandra	B	27.10	25.59	20.65	4.94	
	L	38.43	37.73	33.66	4.07	
	Pods	13.90	12.65	7.68	4.97	
Bauhinia purpurea	B	22.50	21.01	12.18	8.83	
	L	30.78	30.03	22.35	7.68	
Bauhinia variegata var. candida	B	28.95	27.53	13.09	14.44	
	L	28.80	25.56	18.12	7.44	
Caesalpinia coriaria	B	30.00	26.31	12.07	14.24	
	L	47.30	43.98	19.85	24.13	
Caesalpinia pulcherrima	Pods	28.40	24.47	8.04	16.43	
Cassia bacillaris	B	44.10	38.56	12.18	26.38	
	L	35.00	32.53	23.24	9.29	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
Cassia fistula	B	29.20	27.33	10.38	16.95	11.6 (4)
Cassia nodosa	B	37.10	35.20	13.99	21.21	
Enterolobium cyclocarpum	Young B	24.87	24.43	21.25	3.18	
	Old B	21.05	21.05	3.33	17.72	Result not Reported
	L	27.86	26.73	22.34	4.39	(3)
Erythrina HSPA-8261	B	15.72	13.66	10.31	3.35	
	L	21.79	20.22	17.07	3.15	
Erythrina variegata var. alva	B	20.30	18.05	14.45	3.60	
	L	26.52	25.63	22.44	3.19	
Leucaena glauca	B	30.24	28.77	22.65	6.12	4.0 (13)
	L	38.04	36.72	27.77	8.95	
Lonchocarpus domingensis	B	26.73	24.76	19.81	4.95	
Lonchocarpus latifolius	B	26.95	25.94	22.38	3.55	
	L	21.91	21.43	17.44	3.99	
Lonchocarpus violaceus	B	21.60	19.77	16.74	3.03	
	L	29.36	27.84	25.31	2.53	
Pithecellobium dulce	B	29.70	26.17	14.33	11.84	30.0 (6)
	L	37.50	35.03	29.37	5.66	
Prosopis chilensis	Young B	22.10	20.23	17.09	3.14	
	Old B	43.60	35.34	24.72	10.62	
	L	43.90	41.48	35.36	6.12	
Samanea saman	Young B	27.84	25.83	22.17	3.66	
	Old B	15.00	14.20	5.89	8.31	
	L	27.40	25.11	20.68	4.43	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
MALVACEAE						
Hibiscus rosa-sinensis	B	22.34	20.39	18.19	2.20	
	L	26.36	25.60	22.69	2.91	
Thespesia populnea	B	34.24	28.49	19.38	9.11	
	L	35.42	34.61	28.55	6.06	
MUSACEAE						
Musa paradisiaca ssp. sapientum	L	21.38	21.28	19.68	1.60	
MYRTACEAE						
Eugenia (unknown)	B	22.20	17.31	7.07	10.24	
	L	40.90	38.14	12.23	25.91	
Eugenia aquea	B	19.45	17.15	6.50	10.65	
	L	25.26	23.18	9.72	13.46	
Eugenia cumini	Young B	25.61	15.58	6.06	9.52	
	B	30.10	26.48	11.23	15.25	
	L	29.66	26.83	11.32	15.51	
	Galls	8.40	7.71	3.99	3.72	
Eugenia floribunda	B	31.85	30.08	9.75	20.33	
	L	25.96	24.66	11.43	13.23	
Eugenia grandis	B	32.20	24.63	8.86	15.77	
	L	33.66	30.44	11.07	19.37	
Eugenia myrtifolia	B	24.71	22.32	12.03	10.29	
	L	38.36	35.68	21.18	14.50	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
Eugenia paniculata	B	24.57	22.14	9.11	13.03	
	L	37.60	34.40	16.90	17.50	
Metrosideros collina	B	28.10	25.14	9.08	16.06	
	L	38.20	35.44	16.84	18.60	
OLEACEAE						
Ligustrum ovalifolium	B	40.33	38.32	30.03	8.29	
	L	25.72	25.10	18.41	6.69	
PALMAE						
Areca catechu	Fruits	8.10	7.58	5.61	1.97	
PROTEACEAE						
Macadamia integrifolia, No. 246	Green husks	32.48	30.85	20.42	12.06	
	Ripe husks	28.30	27.01	18.14	10.16	
Macadamia integrifolia, B-818	Green husks	21.75	20.59	14.59	6.00	
Macadamia tetraphylla	Husks	15.58	14.22	7.86	6.36	
RHIZOPHORACEAE						
Rhizophora mangle	B	44.44	39.43	26.37	13.06	
	L	47.04	40.39	29.87	10.52	
RUBIACEAE						
Paederia foetida	B	29.64	27.46	24.23	3.23	

(Continued)

TABLE 1. The Tannin Content of Some Plants in Hawaii *(Continued)*

SCIENTIFIC NAME	BARKS LEAVES	TOTAL SOLID	SOLUBLE SOLID	NON-TANNIN	TANNIN %	TANNIN % (LITERATURE)
RUTACEAE						
Murraya exotica	B	26.24	24.95	21.11	5.13	
	L	31.86	29.97	25.87	4.10	
SAPOTACEAE						
Mimusops hexondra	B	34.90	31.10	17.74	13.36	
	L	28.26	26.78	16.25	10.53	
STERCULIACEAE						
Heritiera littoralis	B	24.90	22.76	11.26	11.50	
	L	21.42	20.38	13.30	7.08	
Waltheria americana	B	38.55	37.48	19.94	17.54	
	L	37.03	36.28	27.61	8.67	
VERBENACEAE						
Citharexylum caudatum	B	40.10	38.71	28.87	11.23	
	L	48.45	46.86	34.71	13.74	
	Fruits	50.95	49.53	40.52	9.01	
Citharexylum spinosum	B	34.50	33.03	24.67	8.36	
	L	39.80	38.63	30.37	8.26	

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